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Aerosol processing in ECHAM5-HAM

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Not only do aerosol particles influence cloud properties, but cloud processing also changes the aerosol. Particles are scavenged by nucleation and coagulation, and subsequently incorporated into cloud droplets and ice crystals. This removal may be especially important for ice nucleating particles, because the most efficient ice nuclei are present in very low concentrations. On the other hand, when a droplet evaporates, all collected aerosol particles are re-emitted as one internally mixed particle. This in-droplet processing changes the physical and chemical properties of the aerosol particles. The particle size spectrum shifts to larger sizes (e.g. Hoppel et al., 1990). Henning et al. (2004) report a decrease in the activated aerosol fraction with decreasing temperature and attribute it to the release of cloud condensation nuclei during the Bergeron-Findeisen process. Rosinski & Morgan (1991) found that the re-emitted particles can in turn serve as ice nuclei for condensation freezing.

We have attempted to model these processes in the global aerosol-climate model ECHAM5-HAM (Stier et al., 2005). For in-cloud aerosol processing, two additional modes have been introduced into the aerosol module HAM: one for particles in droplets and one for particles in ice crystals. Aerosol activation and collisions with droplets or ice crystals are parameterized. Assuming that each evaporating droplet releases only one processed particle, the number of in-droplet aerosol particles is equivalent to the number of cloud droplets, which is already predicted in ECHAM5 (Lohmann et al., 1999). Changes in the in-droplet aerosol particle number through activation, sedimentation, autoconversion, self-collection, accretion, freezing, melting of ice crystals and evaporation can be calculated analogously. In contrast, the number of in-ice aerosol particles is not equivalent to the number of ice crystals (parametrised by Lohmann (2002)) because the Hallet-Mossop ice multiplication mechanism leads to new ice crystals formation on ice splinters rather than on ice nuclei. Upon evaporation

or sublimation of the hydrometeor, the released aerosol particle needs to be attributed to the correct interstitial mode according to its mean radius.

These processes alter the aerosol population in the model and therefore influence subsequent nucleation events and aerosol-cloud interactions in general. This will be demonstrated by single-column model results in comparison to different observational data.

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